OBSERVATIONS ON TARSIUS FUSCUS.

BY HARRISON ALLEN, M. D.

The Academy of Natural Sciences of Philadelphia possesses an adult female of *Tarsius fuscus* which through the courtesy of the curators I have recently dissected. The specimen was purchased of Mr. H. A. Ward of Rochester, and is without locality. I propose to describe the superficies, auricle, rugæ, bones and muscles, and compare them especially with the account of the corresponding parts in the allied species *Tarsius tarsius*, as given in Burmeister's monograph.[1] This memoir, elaborately detailed and beautifully illustrated by the author, stands in such high repute that anatomists have accepted the account of the genus as final. Mivart and Muir in their descriptions of the structure of the Lemuroidea[2] omit *Tarsius*. Nevertheless, I have been induced to make this record because of the specific independence of the Academy's specimen, as well as for the reason that variations in structure should be made the subject of special scrutiny. Apart from these considerations, I believe the warmest admirer of the memoir will admit that the teeth are imperfectly described, and the references to the mechanism of the limbs inadequate. When a muscle is not described in this essay, it will be understood that Burmeister's account has been found to agree in all respects with my own.

The abdomen had been opened, the symphysis pubis divided and the organs of generation, as well as the greater part of the intestines, removed before I received the specimen.

THE SUPERFICIES.

The fur generally is long and silky. The tips on the back and sides are dark brown, on the crown and sides of the neck gray, with a disposition to become lighter in hue toward the rump. The hair of the head has a subtip of obscure chestnut, elsewhere with the exceptions named, the basal two-thirds are dark plumbeous. On the under surface of the trunk the fur is light at the tips, while on the inner side of the thigh it is almost white. The inner parts of the

[1] Beiträge zur näheren Kenntniss der Gattung Tarsius, von Hermann Burmeister. Berlin, 1846, 4°, pp. 140, pls. vii.

[2] Zool. Trans., VII, 1866.

forearm, the leg and the tarsus as far as the midtarsal line, are covered with sparse short unicolored light gray hair; the face is well covered with short hair, the snout alone being naked. The tail at the basal inch is marked by the same character of hair as the rump. The proportion of plumbeous hair at the base is, however, less. The remaining part of the tail is hairless, except at the terminal three inches where a conspicuous pencillated arrangement of obscure black hair is seen. The flexor surfaces of contact of the thigh and leg are naked, as also are the palms and soles.

REMARKS ON THE SPECIES OF TARSIUS.

Burmeister gives an elaborate synonymy of *T. spectrum*, as denominated by him—the *T. tarsius* of this essay—and refers to and figures a second species which he names *T. fischeri*. I find the Academy's specimen answers to the description of the species last named. But Burmeister had previously described this form under the names of *T. fuscus*. Geoffroy subsequently named it *T. fusco-manus*. Forbes[3] decides without criticism that the names *T. fusco-manus* and *T. fischeri* are synonyms of *T. fuscus*. In the same volume *T. spectrum* is changed to *T. tarsius*. I have accepted this plan of naming the two species, and thus the Academy's specimen becomes *T. fuscus*. Mr. Lyddeker informs me by post, that while he uses the name *T. fusco-manus* in his work on Geographical History of the Mammalia, he would now accept *T. fuscus*. A. B. Meyer[4] employs *T. fusco-manus*, though changing it to *T. fuscus* in a later publication, which unfortunately is not to be found in the libraries of this country. The author last named, described in the above series a new species under the name *T. philippensis*, characterized by possessing naked tarsi and tail. Professor Meyer writes that he has since described a fourth species under the name *T. sangirensis*, an account of which has not come to hand. The genus, therefore, now contains four accredited species, *T. tarsius*, *T. fuscus*, *T. philippensis* and *T. sangirensis*.

In discussing the synonymy of *T. spectrum*, Burmeister states that *T. daubentonii* is "blackish and ash-gray" in color; *T. bancanus*[5] recalls in its dark colored fur the foregoing. *T. spectrum* is "yellow

[3] Allen's N. H. Libr., Primates, 1894, I, p. 21.

[4] Abhand. u Berichte des Köngl. Zool. u Anthropolog.-Ethn. Museums zu Dresden, 1894, I.

[5] I have carefully studied the account of *Tarsus bancanus* Horsfield (Nat. Hist. Java). It has minute lateral incisors and no upper central incisors. The premolars and molars together number but five; it is probable that the first premolar is absent. The tarsus is less elongated, the ears are smaller and the tail less pencillated than in *T. fuscus*. The form is most likely immature.

brown-gray" with a light dash of "red-brown" on the forehead, the back and upper side of the thigh; the sides of the head and neck are dark brown, the breast whiter. The tip of the tail is yellow and bristle-like. *T. fischeri* (the *T. fuscus* of this paper) is of a reddish yellow-gray, with brown-gray side of head and neck, a clear yellow-white spot on the base of the ear, and a red-brown tip to the tail. Two conclusions can be drawn from these excerpts: one that Burmeister's account of the specific distinctions is not satisfactory, and that the Academy's specimen is remote from *T. tarsius*. It is in the broadest possible way contrasted with the coloration of the figure in Burmeister's memoir. Here the fur of the body and the limbs is of a uniform yellow-gray, the head being somewhat darker, the tip is scarcely more densely furred than the rest of the tail and not differently colored.

THE AURICLE.

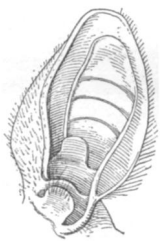

Fig. 1. The auricle of *Tarsius tarsius* after Burmeister.

The auricle is more rounded than in *T. tarsius*. A distinct internal basal lobe is present, which, however, is folded in against the auricle. The outer border ends abruptly at the middle of the large, rounded external basal lobe, which is absent in the species just named. The antitragus is convex and projects but to a less degree than the foregoing, and is separated therefrom by a deep notch (*incisura auris*). The parts are carried well down toward the neck, thus forming a true conch. It is marked within, as in *T. tarsius*, by four transverse ridges, the lowest of which (antitragus) forms a conspicuous lobe. The above comparison is based upon the figure in Burmeister's memoir and the original of the Academy's specimen.

Fig. 2. The auricle of *Tarsius fuscus*.

Burmeister states that the ear on the whole resembles in part that of bats and of rodents. Concerning the first named it certainly bears a comparison with the Pteropodidæ, and (in less degree) the Rhinolophidæ in the absence of the conspicuous fold at the border of the external auditory meatus held by the writer to be a rudiment of the tragus. In no bat, however, is the large transverse fold (antitragus) known.

THE HANDS AND FEET.

The nails of both hands and feet, with the exception of those of the second and third toes, are almost entirely concealed by epidermis. They are, indeed, mere scales, which apparently represent the lowest possible phase of development. Those of the feet are as in the hands, excepting those of the second and third toes. The well-known prorect claws have been aptly compared to thorns on a rose bush. They stand at an acute angle to the sharply flexed second phalanges and permit the broad toe-tips to project to a greater extent than in other toes. I venture in this connection to make a suggestion as to the use of these claws. They are fur dressers and parasite searchers for the head and shoulders. It is a matter of common observation that ecto-parasites are prone to fix themselves about the face and ears. A palmate-finger-tipped animal would be placed at a disadvantage at the toilet. It is probable that when the claws are in use the fourth and fifth fingers are flexed.

The palmar callosities are marginal to the thenar and hypothenar eminences. The basal pads in the digits are large—one is proper to the fourth digit. Burmeister simply states concerning the two basi-digital pads that they lie at the base of the middle and following finger.

In the foot the hallucal and hypothenar pads are strictly marginal. They join at the wrist. A metatarso-phalangeal pad lies axial to the third digit. A large pad lies axial to the phalanges of the hallux. It projects into the first inter-digital space and is well displayed when this space is defined from the dorsum. All three pads are in effect callosities to the metatarsal and the metatarso-phalangeal joints except the first, which overlies in part the powerful *Adductor pollicis*.

The pad of the first toe is opposed to that of the fifth toe. The manner of insertion of the *Adductor pollicis* would naturally have a tendency to pull the entire digit to the ulnar border while flexing the phalanges. The location of the tendon is seen without dissection. The hallucal pad overlying this muscle in part is an interesting structure. This portion of the manus and pes in mammals generally, so far as I know, is free from callosities. But in *T. fuscus* the pad is the largest in the foot and projects toward the sole so as to suggest an important function in grasping.

Burmeister does not acknowledge the marginal pads to be present, but describes three unequal elliptical pads which answer in part to the free basal segment; the middle corresponds to " den beiden ersten Zehen " (second and third digits), the third, the smallest but longest on the outer (fibular) border of the " zwei letzten Zehen " (fourth and fifth digits). Thus no statement is made of the extent to which the pollical pad overlies the first inter-digital space, as is seen in the Academy's specimen, and of the third pad lying to the outer side of the last two toes. In the Academy's specimen it is distinctly inter-digital.

THE SKULL.

The skull of *T. fuscus* differs from that of *T. tarsius* in the tympanic and petrous portions of the temporal bone being greatly inflated, in the orbital border of the malar bone being notched instead of perforated, and the orbital plate of the frontal bone being smooth instead of furnished with a tuberosity over the inner border of the optic foramen. A skull of *T. tarsius* in the possession of the Academy of Natural Sciences of Philadelphia is older than that of *T. fuscus*, yet the position of the para-conules and the meta-conules is cleanly defined.

The infra-orbital canal is minute; the post-glenoid foramen is conspicuous. The union of the external pterygoid plate with the petrous portion of the temporal bone is met with in some short faced types in Chiroptera. The interesting comment is made that in those human crania in which the external pterygoid plate unites with the spinous process, which in its turn joins the squama and lies directly against the petrous portion of the temporal bone, the essential features of *Tarsius* are repeated.

THE TEETH.

The Lower Teeth.—I have lately concluded that anatomical descriptions should be framed when practicable on the basis of etiology. Assuming that the shapes of the upper teeth are results of dynamic forces acting through and by means of the lower teeth, the last named teeth should be described first. The incisors are conical, acicular, and do not touch in the median line; the canines are larger than the incisors and slightly inclined forward. The premolars are contiguous and gradually increase in size from the first to the third. In the molar series the small paraconid and larger protoconid are opposed and merge so as to form a trenchant transverse ridge on the

crown. The molars increase in size from the first to the third, the last named alone having a marked posterior commissural cusp, though a faint rudiment of it can be discerned in the first and second.

Fig. 3. The Lower Teeth of *Tarsius fuscus.*

The anterior eminence is seen in all, though it is least conspicuous in the first tooth. The large metaconid is separated from the small hypoconid by a deep valley. The sharp posterior commissure is continuous with the apex of the hypoconid. In the first and second molars the commissure is straight and transverse, but in the third tooth it is prolonged backward; beyond it, the swollen contour of the tooth projects and yields the impression of being a supplemental cusp; so that the series when viewed from buccal aspect gives to the first and second molars two denticles, while for the third molar there are three. A cingule is sharply defined at the basis of the paraconid and metaconid. All the lower teeth have cingula. In the incisors, canines and premolars they are entire or nearly so; in the molars they are buccal only.

The Upper Teeth.—The conical central incisors are separated from one another at their apical thirds. They are sharply worn on the posterior surfaces and faintly grooved on the outer. The lateral is contiguous to the central, but separated from the canine by a narrow interval. The tooth is minute, higher than the central, its tip being on the level of the cingulum of the tooth last named. The canine is smaller than the central incisor. The premolars abruptly increase in size from before backward; the first two are ridged on palatal surface like the canine; the third alone presents on palatal surface a broad basal cusp.

Fig. 4. The Upper Teeth of *Tarsius fuscus.*

The molars are trituberculate with acicular cusps. Slight indications exist of the beginnings of cusps (conules) on the commissures uniting the protocone with the paracone and metacone. The cingulum is not complete in any of the molars, though nearly so in the first and third. In the second no trace of it exists on the palatal aspect of the second molar, the figure represents the line with too much emphasis.

The protoconids and paraconids are received in interdental spaces of the upper jaw. The hypoconids occupy the valleys of the upper molars. The valleys of the lower molars embrace the protocones. The interdental spaces of the lower jaw are occupied by the metacones. The minute cusps on the ridges connecting the paracone and mesocone with the protocone are met with also in *Lemur*. The disposition is an ancient one, since it is seen in *Chriacus* of the Puerco beds. In *Anaptomorphus* and *Pelycodus* it is less marked, if indeed indubitably present. Theo. N. Gill[6] and Max Schlosser[7] place *Tarsius* in a group distinct from the Lemuroidea, but closely related thereto. C. E. Hubrecht[8] removes the form absolutely from proximity to the lemurs, and gives it a place in the phyllum of the monkeys and men. C. Earle[9] considers *Tarsius* to be an annectant type between the apes and lemurs.

The wear is first on the ridges between the protoconids and paraconids and the anterior of the two ridges of the molars, and between the hypoconid and the posterior of the two ridges.[10]

THE RUGÆ.

The palatal rugæ are nine in number. The first five lie between the premolar and canine teeth; they answer to the abruptly narrowed part of the hard palate, and while composed of right and left parts are irregular and crowded. The remaining four are regular and undivided. Directly back of the incisors is a median part with two minute depressions.

THE BRAIN.

The cerebrum is without sulcus on the spheno-temporal lobe. The olfactory lobe is much larger in Burmeister's figure than in the Academy's specimen. The flocculus is large and is received in a deep recess on the temporal bone. Burmeister states that the flocculus is present in *T. tarsius*, as we would expect; but according to his figure it must have had an absolutely different form from that seen in *T. fuscus*.

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[6] Arrang. Fam. Mam., Smith. Inst. 1872, 54.

[7] Beiträg zur Paläontolog. Osterreich-Ungarn, 1888, 54.

[8] Hubrecht's position is elaborately given in Gegenbaur's Festschrift 1896, 163. The teeth are compared and figured but not described. The conules of the upper molars are not defined and thus one of the characters distinguishing *Tarsius* from *Anaptomorphus* is not given.

[9] Science, 1897, 60.

[10] The superior upper incisor, lateral incisor and premolar in a specimen in the American Museum of Natural History are exactly as in that of the Academy.

THE MUSCLES OF THE LOWER JAW.

Unlike other forms of *temporal* muscle, the superficial and posterior fascicle overlies to a slight extent only the anterior and deeper part, but in the main arises separately from the skull. It can be raised easily by the director just above the auditory meatus and separated from the anterior fascicle by a little artificial dissection.

The *masseter* muscle arises from the inferior orbital margin. The anterior surface as it overlies the lower jaw reaches a line answering to that of the third molar, almost as far as the anterior edge of the line of origin of the muscle. But its insertion is strictly confined to the angle of the jaw; thus a probe can be passed between the anterior third of the muscle and the lower jaw.

The *digastric* muscle is without tendinous intersection, and is inserted almost the entire length of the lower jaw.

THE MUSCLE OF THE SUPERIOR EXTREMITY.

The muscles which are attached to the occiput and cervical vertebræ on the one part and the shoulder girdle and the side of the chest, humerus and bones of the forearm on the other, constitute a natural system, though they are variously distributed in the generally accepted myologic scheme.

I place in this system the following muscles, the grouping by brackets indicating the association through annectant fascicles:

{ Sterno-cleido-mastoideus.
{ Trapezius.

{ Splenius.
{ Scalenus anticus.

{ Transversalis colli.
{ Pectoralis major.
{ Serratus magnus.

{ Deltoideus.
{ Pectoralis major.
{ Brachialis anticus.

Rhomboideus.

Levator anguli scapulæ.

Latissimus dorsi.

The *Sterno-Cleido-Mastoideus* is a sheet whose fold[11] lies at the median border. The clavicular and sternal origins are continuous,

[11] For an opinion entertained respecting muscles which are composed on the plan of a folded sheet, see a paper by the author on the Muscles of the Limbs of the Raccoon (*Procyon lotor*), Proceedings of the Academy of Natural Sciences of Philadelphia, May, 1882.

and are concealed by the upper margin of the *Pectoralis major*. The clavicular sheet makes up the bulk of the muscle and constitutes the superficial fascicle. The sternal sheet is thicker than the foregoing and constitutes the deep fascicle. The *Splenius* lies in part between the two fascicles. The extent of the insertion of the muscles, namely, along the entire length of the occipital ridge (*linea semicircularis ossis occipitis* of Burmeister) is noteworthy. The *Trapezius* sends a slip to the posterior border of the foregoing sheet at a point answering nearly to the level of the axis. Burmeister gives two distinct origins with a triangular interval between them. No mention is made of the clavicular and sternal fascicles being united at the median border of the muscle.

The *Trapezius* is without a capitate slip. The upper fascicle, confined to the cervical region, is small and inconspicuous. The middle fascicle is continuous with the foregoing and ends abruptly about on the line of the inferior end of the vertebral border.

The *Splenius* is a broad simple sheet. It sends a small fleshy slip to a superior angle of the scapula and a broad tendinous slip to the *Scalenus anticus*.

The *Transversalis colli* can be traced to the junction of the superficial and deeper parts. The deep fascicle merges with the above near the insertion; both fascicles are beautifully delineated in Burmeister's plate. The terms in which the *Pectoralis major* are defined present a scheme as simple as any found elsewhere in the mammals. It is of interest, therefore, to find two parts, a superficial and a deep part present, and also to note that the muscle can not be separated absolutely from the *Transversalis colli* and the *Deltoideus* without artificial dissection.

The *Pectoralis major* is small and composed of two fascicles. The sheet is not folded. The superficial fascicle consists of an upper and lower congeries of fibres, which are distinguished by their trend rather than by relation. The fibres of insertion are continuous inferiorly with the *Deltoideus*.

The *Transversalis collis* is traceable to the under surface of the *Pectoralis major*. This is in harmony with the plan seen in *Felis* The *Serratus magnus* is directly continuous with the *Transversalis colli*, and demonstrates in a satisfactory manner that these two muscles form parts of the same sheet.

The *Deltoideus* acts at the insertion of the outer (acromial) fascicle as a muscle of union between the *Pectoralis major* and the *Brach-*

ialis anticus. Accepting this union as valid, the cephalo-humeral system ends by the insertion of the *Brachialis anticus* upon the ulna.

The *Brachialis anticus* is a large, powerful muscle; it arises by two heads, one in continuity with the *Deltoideus* at the pectoral ridge, and the other (the larger) from the outer surface of the shaft just below the origin of the outer head of the *Triceps.* It has a broad tendinous insertion on the ulna. It is more important apparently than the *Biceps*, and unlike the same muscle elsewhere in the mammalia it is not associated with the *Triceps.*

The *Rhomboideus* is small without capitate slip. An important difference is here noted in Burmeister's description. The *Rhomboideus* is figured with an accession about the position of *Rhomboideus major*, and a large muscle resting on the *Splenius* named *Levator posticus scapulæ* which is the same as the capitate fascicle of later writers. The Academy's specimen shows no muscle intervening between the *Sterno-cleido-mastoideus* and the *Splenius.*

The *Levator anguli scapulæ* arises from the transverse processes of the fifth to the seventh cervical vertebræ, and is inserted on the superior angle of the scapula.

A muscle arises from the front of the atlas in association with the *Longus colli*, and is inserted upon the acromion in connection with the *Trapezius.* This is the *Levator anticus scapulæ* of Burmeister's figures, but is not described.

The *Latissimus dorsi* is without axillary arches and arises entirely from the dorsal aponeurosis, where the muscle is 23 mm. wide. This is also the case in Burmeister's specimen. The slip to the olecranon is in close union with the connective tissue over the median nerve and brachial artery, and the impression is received that the slip protects these structures from the effects of friction and pressure.

The other muscles not embraced in the preceding group are the following:

The *Omo-hyoideus* is broad, conspicuous and without intersection.

The *Biceps flexor* is relatively a weak muscle. The association with the *Coraco-brachialis* conforms to the primate type.

The *Triceps* muscle is fully described by Burmeister who, however, includes it in the slip to the olecranon from the *Latissimus dorsi.* The third head (*Anconeus tertius*) arises from the supra-condyloid ridge in part. The three heads do not form a single tendon of insertion. The first two heads are almost separate and measurably distinct from the third. The *Anconeus* constitutes a

thick mass of minute fibres occupying the interval between the humerus at the epicondyle and the olecranon.

The *Supinator longus* is inserted on the dorsal aspect of the *trapezium* and not on the distal part of the radius, though it is held down firmly to that bone. This result has been obtained after a careful dissection. According to Burmeister the tendon runs along the edge of the radius and turns toward the carpus—before reaching this region, however, it is attached to the outer and lower end of the radius, being somewhat broader as it does so. It passes under the *ligamentum carpi dorsalis.*

In his account of the *Supinator brevis* Burmeister does not mention the ossicle in the tendon of origin, which was present in the Academy's specimen.

The *Palmaris longus* is in closer relation to the *Flexor carpi ulnaris* than is the muscle first named to the *Flexor sublimis digitorum.*

The *Flexor sublimis digitorum* and *Flexor profundus digitorum* are distinct with the exception of a delicate tendon which unites the muscles as they cross the wrist.

The *Flexor profundus digitorum* consists of two divisions; one for the first and second digits is the main mass and arises from the radius, the other passes to the remaining digits. Each division is made up of two heads. The above account is distinct from the one elaborately stated by Burmeister, who gives three heads for the muscle, the first as in this essay, the second two heads and an ulnar spindle-shaped fascicle. It is at the junction of the last named part with the others at the wrist that the conjugate tendon is fixed.

The *Flexor longus pollicis* arises by two heads, one from the epitrochlea and the other, a long one, from the proximal one-half of the shaft of the radius. It sends a delicate slip to the *Flexor profundus digitorum* at the wrist and another to the *Flexor sublimis digitorum* at the metacarpo-phalangeal joints.

The *Extensor carpi radialis brevior* arises in common with the *Extensor communis digitorum* and quite distinct from the *Extensor carpi radialis longior*, and, therefore, trends from the epicondyle itself.

The *Extensor carpi radialis longior* is in common origin with the *Supinator longus* and, therefore, trends from the bold crest over the epicondyle. The carpal extensors are not related to each other, but to the adjacent muscles which lie in separate physiological grouping.

The radial carpal extensors are inserted upon the radial side of the base of their respective metacarpal bones. These facts are significant since they point to flexion of hand or forearm, while the latter is semiprone, which is the position proved by the study of joints to be characteristic.

The *Extensor carpi radialis longior* goes with the *Supinator longus* since the two are united, and the *Extensor carpi radialis brevoir* goes with the *Extensor communis digitorum*, but the *Extensor carpi ulnaris* does not go with the *Extensor minimi digiti* in the sense that the two are united.

The *Extensor communis digitorum.*—This muscle is the more superficial of the two extensors. It does not supply the first finger. It is composed of two slips which separate at the proximal third of the forearm and are far apart at the wrist; the inner (radial) passes to the second, third, fourth and fifth fingers, and the outer (ulnar) to the fourth and fifth. Thus the fourth and fifth fingers are doubly supplied. Burmeister separates the last named divisions under the name of the *Extensor digiti quarti et quinti*, but the remaining part is not the *Extensor digiti indicis et medii* unless we accept this fascicle as having a wider range of insertion than is normal to *T. tarsius.*

Assuming that all the extensors (excepting those of the first finger) described by Burmeister are embraced in the above account, a large muscle in the Academy's specimen remains undescribed. This muscle which is analogous to the *Flexor profundus digitorum* is much smaller than the *Extensor communis.* It arises from both bones of the forearm but not from the humerus, and is inserted into all five fingers. The tendon to the first finger is given off high up, but unites with an aponeurotic layer which holds together the tendons to the second, third and fourth fingers. The tendon to the fifth finger is next longest to the first and is without aponeurosis.

The *Extensor communis digitorum* sends a slip high up from the belly; it passes through a separate sheath at the wrist (at the head of ulna) and goes to the fourth and the fifth digits. This probably is the *Extensor minimi digiti.* The main muscle is distributed to all the digits.

The *Extensor minimi digiti* arises entirely from the ulna and supplies all the digits. Hence the fifth digit receives three extensor tendons.

The *Extensor pollicis longus.*—This muscle is normal to *T. tarsius.* It is the same as the *Abductor pollicis longus* of Burmeister.

The *Extensor pollicis longus* of Burmeister is not present in *T. fuscus*. It may be found in the pollical slip of the deep extensor as named in the foregoing paragraph.

The *Flexor pollicis brevis* and the *Abductor pollicis brevis* form one muscle. Burmeister separates them.

The *Abductor pollicis* arises from the fibrous tissue deep in the palm over the *Palmar interossei*. It has no bony origin whatever. Burmeister assigns an origin from the third metacarpal bone. His figure gives the impression of an origin from the fourth metacarpal.

The *Opponens pollicis* is absent. Burmeister describes and figures this muscle. The *Abductor indicis* is a small muscle; it is described by Burmeister.

The *Abductor minimi digiti* embracing the *Flexor brevis minimi digiti* are as in Burmeister's description. The muscles are imperfectly differentiated.

The *Palmar interossei*.—The muscles occupy the opposed sides of the second and third digits, and of the third and fourth digits as given by Burmeister. The pair of muscles for the third and fourth fingers form a fleshy union at the distal end of the first phalanx and the proximal end of the second. Traction flexes the finger powerfully. The muscle to the fifth finger does not flex the finger but extends and abducts it. For the fourth and fifth fingers the arrangement is as follows: A muscle arises from unciform bone and lies on the radial side of the distal end of the fifth metacarpal bone. (1). A fleshy muscle extended forward to the distal end of the first phalanx of the fifth finger. (2). From the same hypothenar mass with the foregoing muscles is of a spindle shape, which lies at the ulnar side of the fourth finger; it becomes a fine thread at the second phalanx into which it is inserted. Of this group Burmeister briefly says, "the third pair is inserted on the opposed sides of the fourth and fifth fingers."

The *Dorsal interossei* are four in number and arranged as follows: Second and third fingers one to each side of the first and second phalanges; one to the radial side of the fourth digit. All the foregoing have spindle-shaped bellies, which arise from the proximal ends of the respective metacarpal bones. A somewhat distinct muscle is pyramidal and arises from nearly the entire length of the fifth metacarpal bone as well as the palmar aspect of the fourth and fifth metacarpal bones. The palmar association of the dorsal muscle is marked and confirms Ruge's thesis that these muscles are derivative

from a palmar group. Burmeister gives the numeration as above, but the muscles are too closely united to agree with *T. fuscus*, while the difference in the ulnar muscle of the fourth finger is not given.

In reviewing the muscles of the hand, both intrinsic and extrinsic, one is struck with the fact that the ulnar division of the hand is more highly endowed than the radial. The extensors of the fingers are connected with the first interphalangeal joints by broader and more powerful bands on the ulnar than on the radial sides. The *Palmar interossei* are much larger and more powerful on the ulnar than on the radial sides of the third and fourth fingers. The *Dorsal interosseous* muscle for the ulnar side of the fourth finger is much broader and thicker than its fellows.

THE MUSCLES OF THE INFERIOR EXTREMITY.

The *Biceps femoris* arises in common with the *Semitendinosus* from the ischial tuberosity. It is with scarcely any disposition to extend down on leg, either in tendon or aponeurosis. The entire process stops at the proximal fourth of the leg. One sheet of aponeurosis passes to the crest of the tibia, and to the intermuscular septum between the *Gastrocnemius* and the *Peroneus longus*. The relations of the muscles are quite as in other mammals. The *Semimembranosus* is without transverse inscription. The *Semitendinosus* possesses one, or at least the belly is digastric. The muscle last named with the *Gracilis* and *Sartorius* form one tripartite muscle.

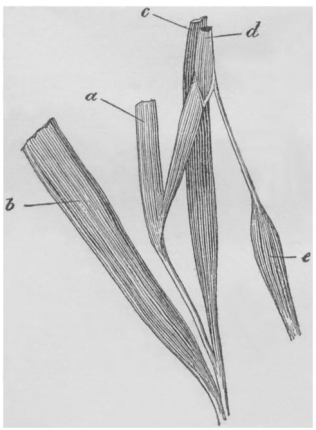

Fig. 5. The hamstring muscles of *T. fuscus*: *a*, gracilis; *b*, sartorius; *c*, semimembranosus; *d*, semitendinosus; *e*, biceps.

The extremely weak *Biceps*, which secures no independent origin, forces one to the conclusion that it is related to the ham strings only, and not to the *Gluteus maximus* whose relations to the femoral shaft are secured through another associate, namely, the sheet I call the "Annectant Mass." Burmeister's account of the *Biceps* is quite different from the foregoing. The muscle arises from the ischial tuberosity and receives a few fibres only from the *Semitendinosus*. The difference is more

apparent than real. It might with exactitude be said that both *Biceps* and *Semitendinosus* have a common ischial stem. Certainly it cannot be said, as Burmeister asserts, that the *Biceps* is the most powerful of the ham strings.

The "Annectant Mass" between the *Gluteus maximus* and the *Semimembranosus* arises from the transverse processes of the caudal vertebræ just below the sacrum by a line 7 mm. in breadth, as well as from the tuberosity of the ischium above the origin of the ham strings. It is inserted by fleshy fibres on the shaft of the femur for a little over one-half of its length. At the caudal origin it is in contact with the *Gluteus maximus* at its ischial origin with the ham strings and at its insertion with the *Adductor magnus*, if, indeed, it may not be said to merge with this muscle. It cannot be freed from fascia without artificial dissection, being continuous with the fasciculation anteriorly and with the firm connective tissue layer over the *Semimembranosus* posteriorly.

Burmeister names this muscle the *Pyriformis*. The mutilation of the Academy's specimen in the region of the pelvis prevented a satisfactory study being made of the muscles arising from the sacrum and inserted on the bones of the inferior extremity. This fact does not prevent the observer from deciding for himself the identity of the muscle here described. The well known disposition of the *Semimembranosus* to secure an origin from the vertebral column makes it probable that a muscle in the same general region which arises from the vertebral column to be inserted upon the femur might be allied to this ham string. I propose to separate it from the *Pyriformis* and place it in a position annectant between the *Gluteus maximus* and the *Semimembranosus*.

The *Gemelli* and *Obturator internus* answer to Burmeister's descriptions.

The *Rectus femoris* is small and weak and is but one-sixth as wide as the main mass of the *Quadriceps extensor*. The origin of the *Rectus* is tendinous with an aponeurotic extension which proceeds upward over the outer surface of the *Iliacus*. The *Vastus externus* is the largest part of the muscle and is almost divided into an inner and outer part. The inner part receives two important accessions from fascicles having extensive fleshy origins from the femur, but the main body of the enormous *Vastus externus* is free from the femur except at the great trochanter and the head of the tibia. The *Vastus internus* resembles the *Vastus externus*, but receives no ac-

cessions. The mass arising from the lower half of the front of the femur is normal.

The leg can be extended on the thigh scarcely to a right angle. Yet the great bulk of the *Quadriceps* is required to do this much.

The patella is small (4 mm. + 2½ mm.) while the patellar groove on the femur is deep and long. This notch is much deeper on the outer than the inner side. The patella scarcely occupies the groove but lies well toward the intercondyloid notch.

The *Plantaris* passes almost entirely to the first toe, a fibrous band passing to the base of the first phalanx of the second toe and another joining the *Transversalis pedis superficialis.*

The *Extensor longus digitorum pedis* passes to the outer side of the tibia as the *Tibialis anticus* and *Extensor longus pollicis* pass to the inner side. It lies beneath the annular ligament and directly in front of the ankle joint, though above the calcaneum it passes under a special ligament which holds it close to the bone last named. At the mid-tarsal region it again passes beneath a special ligament and forms two aponeurotic expansions, the inner supplying the second, third and fourth, and the outer the third, fourth and fifth digits. Tracing these tendons back to their origin it is found that the outer division retains the largest fleshy fascicle.

The *Peroneus longus* (*Peroneus primus* of Burmeister).—This muscle exerts no action on the entire foot except in its effect on the first metatarsal bone. Traction pulls the bone forcibly inward by a bold free motion. It has no effect on the cuboid bone.

The *Flexor communis digitorum* is a large, powerful muscle. It arises from the tibia by fleshy fibres half way down the posterior surface of the shaft. It unites with the *Flexor longus pollicis pedis* to form one tendon at the mid-tarsal region. At this point a strong tenaculum (which serves as a check to extreme contraction) attaches itself to the under surface of the common tendon and holds it to the calcaneum. I venture to call the *Lumbricales* the para-fascicles. The first toe has none; the second one; the third three; the fourth two; and the fifth toes one para-fascicle.

The *Tibialis posticus* is very small; it arises high up in the leg and is chiefly derived from the fibula and the interosseous membrane. The slender thread-like tendon is inserted upon the scaphoid bone.

The *Abductor externus minimi digiti* is the same as described by Burmeister.

The *Abductor internus minimi digiti* of Burmeister could not be traced further than the proximal end of the metatarsal bone, while Burmeister states that it extends along the border of the metatarsus together with the sheath of the *Flexor longus* to be inserted upon the first phalanx.

The *Abductor hallucis* arises from the distal end of the scaphoid bone and is inserted on the fibular side of the first phalanx. The *Flexor brevis hallucis profundus* takes origin from the cuneiform bones as described by Burmeister, but the two heads named by him do not exist nor is there connection with the first metatarsal as he describes. It is inserted on the fibular side of the first phalanx.

The *Abductor minimi digiti* and the *Interossei interni* are as described by Burmeister.

The *Flexor brevis pollicis brevis* is a thick, stout mass arising from the cuneiform bones and inserted upon the fibular side of the base of the first phalanx. Parallel to the foregoing, near the *Transversalis pedis* and inserted just in advance of it, lies a muscle which corresponds in the respects named to the *Transversalis pedis profundus* of Burmeister. But it arises from the ecto-cuneiform bone and has no connection in origin with the shafts of the metatarsi. Even the *Transversalis pedis* is without origin from the second or third metatarsi, but arises from the base of the second metatarsus and thus recalls the *Abductor pollicis.*

The *Abductor pollicis pedis* arises from the tibial side of the head of the second metatarsal bone. It is joined by the *Transversalis* and a slip passes with this muscle to the base of the first phalanx of the great toe, but the main belly is inserted into the second phalanx of the great toe.

Burmeister's account of the "*Abductor hallucis*" is quite different from the above. The muscle arises from the cuboid bone, is intimately associated with the plantar aponeurosis, passes obliquely across the sole, and is inserted on the under part of the first phalanx of the great toe, as well as on the sheath of the tendon of the *Flexor longus pollicis.*

Thus the muscles of the toes are arranged sufficiently different from those of *T. tarsius* to suggest a distinct origin. The thumb is drawn more powerfully toward the center of the wrist than toward the fifth toe. In a word it is less opposable than is the case in *T. tarsius.* The fibres which yield the *Abductor* are not separable from other fascicles which pass from the ecto-cuneiform forward,

and are inserted as one continuous sheet upon the bases of the second and third metatarsi. Nothing comparable to these fascicles are described by Burmeister.

The *Abductor pollicis pedis* is quite as described by Burmeister.

Burmeister gives an account of a muscle named by him *Abductor hallucis* which arises from the plantar fascia and is inserted upon the fibular side of the first phalanx on a level with the foregoing. No such muscle is found in *T. fuscus,* but a number of tendinous fibres pass in its place from the plantar fascia to the *Transversalis pedis.* The *Flexor brevis digitorum* sends a large fascicle to the toe, and it is possible it is this slip which Burmeister has named separately.

The *Abductor digiti minimi extensor* and the *Abductor digiti minimi internus* are distinct muscles corresponding exactly to Burmeister's description.

The *Abductor digiti minimi* arises by two distinct heads instead of one as described by Burmeister. Both muscles touch the belly of the *Palmar interossei* instead of permitting an interval to be defined between them.

The *Extensor brevis digitorum pedis* in addition to its origin from the calcaneum yields a slender tendon from the belly of the *Extensor longus pollicis* high up on the leg. Burmeister does not mention this slip nor is it figured by him. The first, second and third digits possess separate extensors which are specializations from the *Extensor brevis digitorum* of human anatomy.

The *Plantar interossei.*—Seven muscles are seen on the plantar aspect. The first muscle is inserted on the tibial side of the second metatarsal bone; the second and third muscles on opposed sides of the second and third bones; the fourth and fifth muscles on opposed sides of the third and fourth bones; the sixth muscle on the fibular side of the fifth metatarsal bone.

The *Dorsal interossei.*—Three muscles are seen on the dorsal aspect. One on the tibial side of the second metatarsal bone answers to the first *Plantar interosseous.* One on the tibial side of the third metatarsal bone answers to the third *Plantar interosseous;* one on the tibial side of the fourth metatarsal bone answers to the sixth *Plantar interosseous.*

The dorsal muscles are those which at the same time are the most powerful of the plantars. In other words the plantars which are the more powerful occupy in their surfaces of origin the sides of the metatarsal so completely as to be visible from the dorsal aspect of

the foot. They uniformly arise more superficially on the plantar surface and in part overlap the others. The more powerful muscles tend to abduct the metatarsi; the weaker to antagonize these and to adduct the metatarsi.

Burmeister reverses the proportions of the two sets of muscles. The figure (fig. 11, taf. 5) expressly shows the adducting set and named by him the plantar to be the larger and more superficial.

NOTES ON THE MECHANISM OF THE LIMBS.

The superior extremity is small and weak.[12] Flexion of the elbow is but 10 mm. as measured by the excursus of the head of the ulna. The bones of the forearm do not agree with Burmeister's description, while his figure of the relation of the radius and ulna are again quite different from that in *T. fuscus*. Instead of a wide interosseous space the specimen shows a narrow one, the bones are almost in contact except at the middle third where the interval is but one-half mm.

The radius moves scarcely at all on the ulna, so that pronation and supination are not as marked as would be inferred from the size of the *Pronator radii teres* and the two supinators.

The presence of a bold ridge on the outer side of the humerus above the epicondyle answers to the large *Supinator longus* in alliance with the *Extensor carpi radialis longior*.

The hand lies at right angles to the forearm by extreme dorsal traction; the first row of phalanges is semi-flexed, the second row is acutely flexed, while the third row is extended. The thumb is not opposable, but the metacarpal bone is sharply adducted so that the phalanx lies under the index finger. The metacarpo-phalangeal articulation is very loose.

On p. 49, statements are made to account for the longitudinal grasp of the foot. This position places the *Peroneus longus* in admirable phase for drawing the tibial margin of the foot in toward the plane of support. The weight of the body bears not only through the astragalus to the astragalo-scaphoid ligament, but the calcaneum is supported on the sling-like *Plantaris* as well as on the *Gastrocnemius* and *Soleus*.

The amount of strain in the position is indicated by the smooth concave pulley-like surface on the calcaneum, and the insertion of

[12] In a skeleton of *Tarsius* which I identify as that of *T. fuscus* in the American Museum of Natural History, New York, the presternum was found to be cartilaginous.

the muscle last named on the lower edge of the bone. Observation of the specimen when flayed shows a decided antero-posterior curvature of the cervical vertebræ.

The singularly small innominate bone indicates that no correlation can be established between it and the rest of the enormous inferior extremity. The following are the measurements of the bone: Tuberosity to pubis 15 mm.; center of acetabulum to vertebrate margin 2½ mm.; width and length of sacral facet 3 mm.; length of ilium 22 mm. The ischial spine is very prominent and shows exceptional power in the *Obturator internus* and *Gemellus superior*. While the bone is but 28 mm. long the rest of the limb measures 183 mm.[13] The knee joint is remarkable for the great contrast between femoral condyles, the outer being twice as large as the inner. The patellar notch, as already noted on p. 49, is extraordinarily long and deep, being 7 mm. long, while the condyle is but 3 mm. The groove appears to represent on the front of the joint the obliquity of the outer tibial tuberosity on the back.

The fibula joins the shaft of the tibia at the beginning of the distal third. The position of the head is indicated. Burmeister's description corresponds to the above, though from the figures it could be inferred that the shaft of the bone was outlined throughout, i. e., never having been lost in that of the tibia. The excursus of the heel (taken as a measurement of the range of knee joint) is 29 mm.; that of the mid-tarsal joint (taken as a measurement of the ankle movement) is 7 mm.

The astragalus is one-third the length of the scaphoid bone. The scaphoid at the astragalus rests in front and over the calcaneum, but at the mid-tarsal joint the scaphoid is on the same plane with that of the calcaneum. The motion between the scaphoid bone and the astragalus recalls that between the radius and the humerus, the position at rest is semipronation, and the excursus is to yet deeper pronation; there is no supination.

The general aspect of the plantar surface is like that of the forearm in most mammals if the scaphoid and the calcaneum might be compared to the radius and the ulna, while the cuboid and ento-cuneiform bones might be compared with the pisiform bone and trapezium. In *Tarsius* both the cuboid and the ento-cuneiform

[13] The thigh, tibia and foot are each about 60 mm. long when dissected, but in the undissected limb, owing to the flexing of the finger, the foot is 52 mm. long.

bones form conspicuous projections into the sole, and thereby define the sides of a depression in which lie the conjoined tendons of the *Flexor longus digitorum* and the *Flexor longus pollicis pedis*.

The *ligamentum plantare longum* of Burmeister is the same as the suspensory ligament. It extends *pari passu* with the elongation of the scaphoid bone and bears a close resemblance to a tendon of a muscle. It attaches itself to the tibia and the distal end of the scaphoid bone, some fibres being held to the calcaneum opposite the astragalus, others being merged with those forming the posterior ligament of the ankle joint. The metatarso-phalangeal articulations are extremely loose and the toes are so disposed as to show tibial deflection, the longer ones overlapping the shorter. The thumb on the other hand shows fibular deflection being drawn toward the palm by powerful muscles. The first row of phalanges is not extended on that of the metatarsus (as the first row of phalanges is extended on that of the metacarpus) but is on the same line. The second to the fifth toes resemble the fingers in motion and position, but the great toe remains extended.

The weakness of the foot support is doubtless harmonized with the extent of the knee flexion. Hence the muscles of the calf practically disappear in the deep recess between the ham strings. The inclination forward of the trunk is checked by the great mass of the *Erector spinæ* muscles, with which the deep groove between the dorsal and broad transverse processes of the thoracic and lumbar vertebræ correlate. The tail and its muscular power, especially at its base, may be taken as a balance of weight to that of the trunk, the hip joint being accepted as the fulcrum. When the limb is extended the hind feet yield a support too feeble to hold up the body. When the limb is flexed the line of support passes from the foot to the ischium; even then the trunk inclines forward. This inclination is checked by the ham strings. The "spring" consists in the extension from extreme flexion. Although extension at the knee is greatly restricted, the power necessary to the end is expressed in the enormous *Vasti*.

According to De Blainville the respective lengths of the calcaneum and scaphoid bone as seen in *Tarsius* is repeated in *Otolicnus*. Recalling the fact that these forms are now to be placed in different phylla, we recognize that the elongation of the two bones is an adaptive character.

A reasonably good conception of the mechanism of the foot is secured by placing it longitudinally on the upper surface of a small rounded stem. The pollex holds to the side of the stem, the short second and third digits to the top, and the longer fourth and fifth digits to the outer side. These dispositions show how well adapted the foot is for both support and prehension. The method of progression accepted by the animal is not so well shown. But doubtless the "spring" of the limb enables the foot to quickly let go its hold. The arrangement might be called one for longitudinal perching as contrasted to the transverse perching of birds and the chameleon. If the view here expressed be accepted, the positions in which the foot is drawn by Burmeister and Brehm are erroneous. In Burmeister's memoir the grasp is that of the human hand, the thumb being on one side of a small bough and all the other digits on the other. In the main figure of Brehm[14] the foot is transverse to the bough. In the smaller figure it is longitudinal. But the bough is so large in the illustration that it makes but little difference what the position of the foot may be. Cuvier[15] represents the foot in the position here claimed on anatomical grounds to be correct for small boughs. The inference to be drawn is the following: *Tarsius* is specially adapted to spring lightly along small boughs and limbs of trees by the longitudinal perch. It may modify the grasp on large, broad surfaces.

[14] Thierleben, I, 274.
[15] Règne Animal.